M&S in the GIG Environment: An Expanded View of Distributing Simulation

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ABSTRACT

The US Department of Defense (DoD) is currently launching itself into the Global Information Grid (GIG) environment. Although we may not know the full shape of the GIG or even it's implication for Modeling and Simulation (M&S) at this point, there are some significant aspects of the GIG upon which we can build to become capable participants in this new world. The Defense Information Systems Agency (DISA), which is the organization responsible for building the GIG, and the Defense Modeling & Simulation Office (DMSO), which is the focal point for M&S in DoD, teamed to provide critical technical and operational concepts that have the potential to change dramatically the way we look at distributed simulation. Regardless of how the GIG finally emerges, we know certainly that it will be based on a Service-Oriented Architecture (SOA). The GIG comprises four domains that are used to group and categorize the services. DISA is actually working on standards, service stacks, and service definitions. These standards and definitions will provide the core upon which we build M&S services in the future. We will describe how using these services will change the way we look at M&S standards; how existing and emerging data models provide a critical part of the solution; and where we are going with the HLA. In particular we will exploit web services, as they are currently the choice for implementing SOA. Topics included are the web service stack; standards being adopted by the GIG and their implication for service providers; how ontologies, taxonomies and data models play in web services; what standard data models are being used; how M&S needs to look at standards in the light of GIG services; and how this affects the review of the IEEE1516 HLA standard.

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Introduction

In order to leverage the power of information, the information has to be efficiently and effectively distributed and utilized in a parallel manner. Within the armed forces, this task is pursued by Network Centric Operations and Warfare (NCOW). NCOW provides a force with access to a new, previously unreachable region of the information domain. The ability to operate in this region provides the Warfighter with a new type of information advantage leading to a Command and Control (C2) advantage. This advantage is enabled by dramatic improvements in information sharing made possible via networking. With this information advantage, a warfighting force can achieve dramatically improved shared situational awareness and knowledge. The transformation of C2 procedures goes hand in hand with these technical achievements. Although technology is the enabler, the driving factor is the transformation of the forces as a whole.

In this context, the ability to achieve a heightened state of shared situational awareness and knowledge among all elements a force, including allied and coalition partners, is increasingly viewed as a cornerstone of Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) transformation. Emerging evidence from recent military operations and a broad range of experimentation supports the relationship between shared situational awareness and knowledge enabled by NCOW concepts and increased combat power.

The means for accomplishing this in the U.S. Department of Defense (DoD) is the Global Information Grid (GIG). The GIG is a globally interconnected, end-to-end set of information capabilities, associated processes and personnel through which information is collected, processed, managed, stored and disseminated on demand to Warfighters, policy makers, and support personnel.

The GIG is a key enabler of NCW and is essential for information and decision superiority. It will enable C4I integration of joint forces, improve interoperability of systems, and increase optimization of bandwidth capacity thereby dramatically improving warfighting capabilities. The GIG will enhance operational capabilities while providing a common environment for Command and Control (C2), combat support, combat service support, intelligence, and business functions.

The next generation of information technology (IT) supporting Joint Command and Control (JC2) must be much more agile than the C4ISR systems are today. The stand-alone, database centric and message based methods of informing the Commander ended with the concept of the Common Operational Picture (COP). However, the COP is still a quasi-static display of the situation, with latency issues and in the best case, a geo-spatial representation of logistics and intelligence data. What the Warfighter needs for JC2 is an agile process, i.e., tools that are bridging the gap between the information domain and the cognitive domain. There is a clear requirement in the various components of a Net Centric C4I system to utilize Models and Simulations (M&S). These can be the basis for planning and decision support tools, as well as the information processing required for visualization and presentation of information outside the normal COP's physical, geo-spatial domain. There are explicit and implicit requirements for sophisticated processing of that information for situational awareness, decision support, and operational control. Additional requirements are to seamlessly support training, procurement of new components, and testing; in other words, the supply of M&S functionality across the operational context of the GIG.

This tutorial shows the necessity for operational M&S services within the GIG. It will show the general technical constraints of service-oriented architectures and

web- or grid-services, and it will give a first overview of the military GIG in the detail needed for the M&S component- or service-developer to be aware of challenges and requirements. The reference section gives an initial selection of literature in this area.

OPERATIONAL REQUIREMENS FOR M&S SERVICES FOR NCOW

In addition to the well-known and valid arguments to couple, embed, or integrate Command and Control systems and simulation systems for training and testing, the use of M&S functionality within the GIG is directly connected to an improvement of the NCOW value chain. In order to show how this improvement is motivated, the value chain approach, which employs several layered concepts, must be defined:

- The value chain starts with *Data Quality* describing the information within the underlying command and control systems.
- *Information Quality* tracks the completeness, correctness, currency, consistency, and precision of the data items and information statements available.
- *Knowledge Quality* deals with procedural knowledge and information embedded in the command and control system such as templates for adversary forces, assumptions about entities such as ranges and weapons, and doctrinal assumptions, often coded as rules. In future systems, this agile component could be presented by M&S systems. Knowledge quality is the first component related to the common model of the operation.
- Finally, *Awareness Quality* measure the degree of using the information and knowledge embedded within the command and control system. Awareness is explicitly placed in the cognitive domain, i.e., definitely above the level of technical interoperability.

In summary, the ability to share data, information, knowledge, and awareness enables conducting operations more efficiently. The IT value chain reflecting the C4ISR improvements over the recent decades mirrors the NCW value chain. The current C4ISR systems started as database centric and message driven solutions. They were only able to support Data Quality. To support the next level within the value chain, the idea of the Common Operational Picture (COP) had to be introduced. This led to a jump in the quality, i.e., increasing it by an order of magnitude ("a picture says more than 1,000 words"). The reason is that the COP added context to the data, hence increased not only the Data Quality, but also Information Quality. The introduction of M&S to C4ISR adds procedural knowledge in form of models; hence, the next level in the value chain can be supported, leading to another improvement ("a simulation says more than 1,000 pictures?"). Finally, if the M&S services and components are enriched by the necessary metadata describing not only the model, but also its constraints, data requirements, etc., in the future, intelligent software agents will be able to select applicable M&S services to permanently evaluate the situation, work on alternatives, cope with alternative courses of actions of hostile forces, etc. This will equal the use of knowledge embedded in the system; in other words, even the awareness quality may be supported by future C4SIR systems. Figure 1 depicts this idea.

The integration of M&S components into the IT infrastructure is therefore seen as an operational necessity. The technical requirements are given. As with the acceptance of NCOW, the integration of M&S into the GIG faces more cultural barriers than technical challenges.

SERVICE-ORIENTED ARCHITECTURES, WEB SERVICES, AND M&S SERVICES

The current software paradigm to cope with the challenges of net-centric operations such as NCOW is to apply services within service-oriented architectures (SOA). SOA is a collection of composable services. A service is a software component that is well defined, both from the standpoint of software and operational functionality. In addition, a service is independent, i.e., it doesn't depend on the context or state of any application that calls it.

Currently, these services are typically implemented as web services. Services in grids are often referred to as grid services. Although different standards may be used for the implementation of the service, web services and grid services are used as synonyms in this tutorial. The advantage of using web standards in an SOA is that the services can more easily handle distributed applications in heterogeneous infrastructures. Nothing in particular has to be done programmatically to the service, except to enable it to receive requests and transfer results using web-based messaging and transportation standards. In many cases, web services are straightforward and existing software can easily be "web enabled" to create new services usable within an SOA.

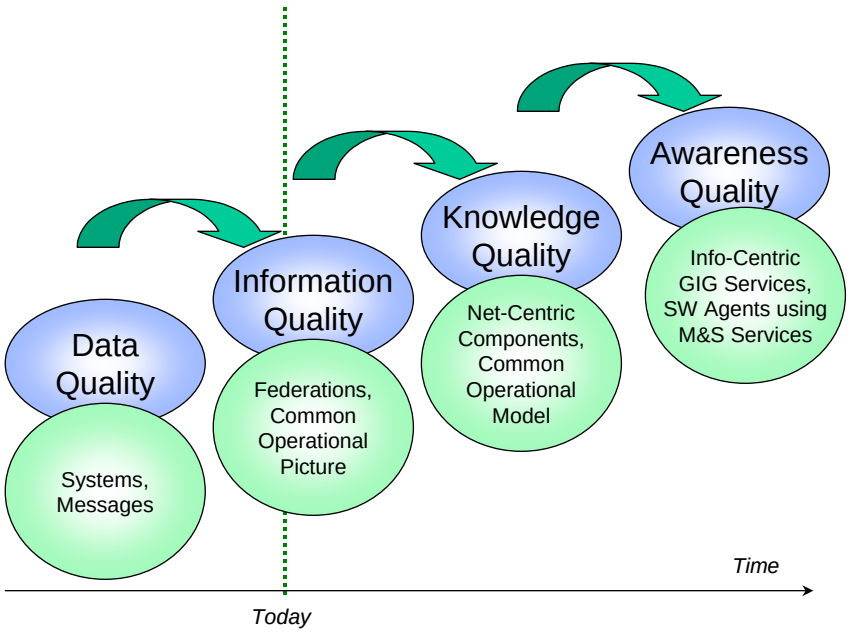

Figure 1. Improving the NCOW Value Chain

The Standards of the Web-Service Stack

Web Services are a set of operations, modular and independent applications that can be published, discovered, and invoked by using industry standard protocols - Simple Object Access Protocol (SOAP)**,** Web Service Description Language (WSDL) and Universal Distribution Discovery and Interoperability (UDDI). It is a distributed computing model that represents the interaction between program and program, instead of the interaction between program and user. Web services can also be defined as discrete Web-based applications that interact dynamically with other web services. In order to make this happen, several sub-functions are necessary:

- *Self-description* of the service functionality.
- *Publishing* the service descriptions using a standardized format.
- *Locating* the service with the required functionality.
- *Establishing* communications with the service.
- *Requesting* the required data to initiate the service.
- *Exchanging* data with other web services, including delivering the results.

The web service vision is that services will work together seamlessly because they are developed to the same standards for self-description, publication, location, communication, invocation, and data exchange capabilities. As all the standards concerned are open, the technologies chosen for web services are inherently neutral to compatibility issues that exist between programming languages, middleware solutions, and operating platforms. As a result, applications using web services can dynamically locate and use necessary functionality – whether available locally or from across the Internet.

Web services are discrete web-based applications that interact dynamically with other web services. Four elementary definitions are needed. These definitions are directly based on open standards:

- Structuring and describing the information to be exchanged.
- Specifying the web service (self description).
- Accessing and communicating with the web service.
- Registering and locating web services.

The first definition describes the *Structure and Description of the Information* to be exchanged. This is done using the *Extensible Markup Language (XML).*

The Object Management Group website gives the most recent definitions applicable to XML. Numerous additional publications deal with XML. Like the Hypertext Markup Language (HTML), XML is directly related to the more general Standard Generalized Markup Language (SGML). XML expanded the browser-oriented use of the Internet in which services provide information to a user via HTML, by enabling service-to-service communication. This paradigm uses the Internet as a communication backbone without requiring a user in the loop to drive this process. Wherever data must be exchanged between two services or applications, XML can be the suitable format for making the data self-describing.

XML can be seen as the foundation on which web services are built. It provides the description of the data to be exchanged as well as storage and transmission formats. It also supports the data transformation from legacy data representations within the applications to a common data reference and exchange model. One of the frequently used arguments against the application of XML is that XML can be inefficient due to its use of strings based on Unicode for capturing the information. However, ongoing standardization efforts on a binary version of XML will help to overcome this problem. In addition to XML itself, the following related members of the XML family are of particular interest for web service applications:

- XML schemas that define data types, content and structure;
- XML namespaces that unambiguously define names;
- Extensible Stylesheet Language Transformation (XSLT) that enable standardized transformation of various XML schemas into each other.

The second definition deals with *Specifying the Web Service*. The main idea behind a web service is that, once it is written, it can be published and registered by the provider. Interested users can then locate it to use the functionality provided. To this end, the necessary information about the functionality of the web service, its location, content, the structure of input and output data, and constraints have to be described. This is done using the *Web Service Description Language (WSDL).* The World Wide Web Consortium (W3C) coordinates the related standardization efforts and publishes the results on its website. WSDL comprises data type messages for data type definitions, operations port type bindings for abstract operations, and port services for service bindings. The data type definitions are XML schemas. A port type is a logical grouping of operations, similar to an object's interface descriptions in the Common Object Request Broker Architecture (CORBA). A port is used to expose a set of operations (as specified by the port types) using a given transport mechanism. Service bindings map messages and operations to transport mechanisms needed for the communication when using the services, such as SOAP bindings, which will be dealt with in the next paragraph. In other words, WSDL specifies what operations and services can be called by specifying which functions, with which parameters, delivering results via which ports in which format. In summary, WSDL uses XML schemas to describe what input parameters are needed, what functions can be called, what output parameters have to be expected, and which protocols have to be used to deliver the input, to invoke the function, and to receive the output.

The third definition is necessary to *Access and Communicate with the Web Service*. The related standard is the *Simple Object Access Protocol (SOAP).* As with the WSDL, standardization of SOAP is orchestrated by the W3C. This specification defines a message framework for exchanging data in XML documents. SOAP provides a minimum level of transport using the Hypertext Transfer Protocol (HTTP), Simple Mail Transfer Protocol (SMTP), or the Multiple Internet Messaging Extensions (MIME) multipart. The use of alternative communication protocols is possible, but HTTP and SMTP are actually applied in most circumstances.

The underlying principle of SOAP is to define simple, one-way mappings for basic functions like *GET* and *POST* for requesting and sending information. This information is contained in XML formatted messages. SOAP defines a mandatory envelope and body that specifies the start, content, and end of the messages, as well as obligatory headers, attachments, encoding, etc. SOAP can be customized with Remote Procedure Call (RPC).

The last definition addresses the *Registration of Web Services*. The provider of the web service must publish its description in form of the WSDL in order to enable other users, including web services themselves, to discover it. To this end, the *Universal Distribution Discovery and Interoperability (UDDI)* framework has been established. UDDI is not a formal standard. It is, however, a comprehensive, open, industry initiative resulting in a directory used to register web services (web service provider) or discover them (web service user). However, UDDI can be seen as something like a "de facto" standard defining a data model in form of an XML schema and SOAP application programming interface (API) that have to be used to register or dis-

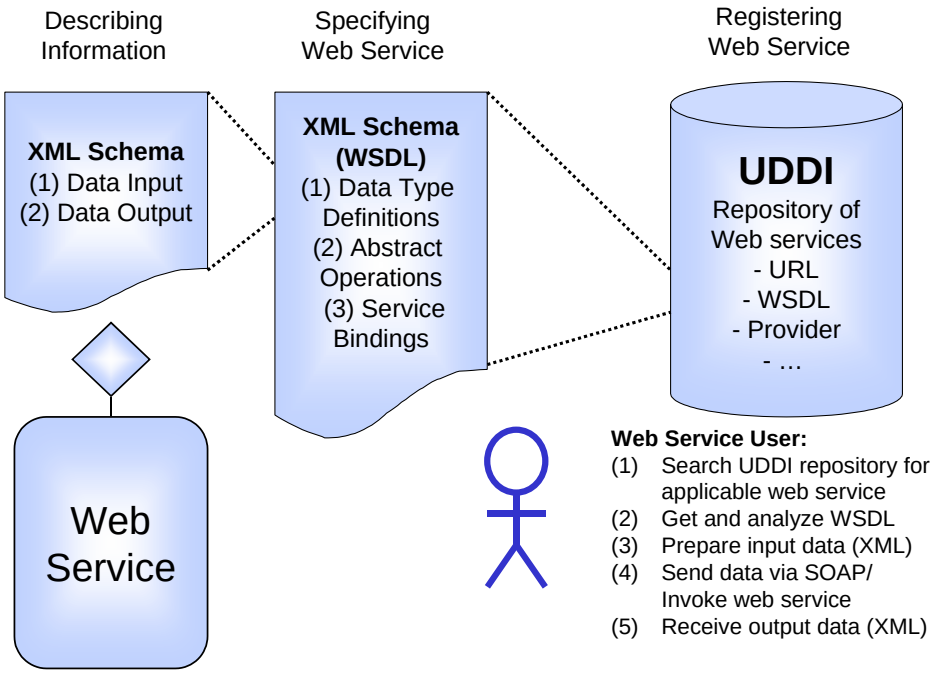

Figure 2. Web Services

cover a web service. An industry consortium founded by Microsoft, IBM, and Ariba supports UDDI.

In summary, web services describe their information exchange requests in form of XML schemas, they are specified using the WSDL, and they communicate using SOAP. The UDDI registry is something like the Yellow Pages to search and discover available web services or to publish additional functionality as a web service provider. Figure 2 shows the various components of the web service related standards framework.

Web-Enabling Components

How can M&S components be web-enabled? The general approach is easy, and particularly so when the component is already prepared for distributed computing. Figure 3 illustrates this process.

- First, the input and output data must be specified. Data modeling – the unambiguous definition of all entities and their relations – is needed. Even without a data model, the information to be exchanged must be unambiguously defined.
- Second, the an XML interface must be build to import and export the data as specified in the first step. Furthermore, the procedures invoked to use the data (or produce them) must be specified using XML descriptions.
- In the third step, these XML descriptions are form the basis of the WSDL description of the services provided by the component. In addition to the procedures and data, descriptions of ports, network addresses, bindings and port types supported have to be added into the respective fields of the WSDL schemas.
- This result describes the web service – or web services – delivered by the component. The only thing left to do is to post it to the UDDI server identified for the supported grid or network. Users will look up WSDL descriptions using the same UDDI server and can connect to and invoke the web services using the information specified in the WSDL block.

Projects within the Extensible M&S Framework (XMSF) program have shown the feasibility of this approach for M&S components. The next step is to bring this these M&S services into the GIG to support the warfighter.

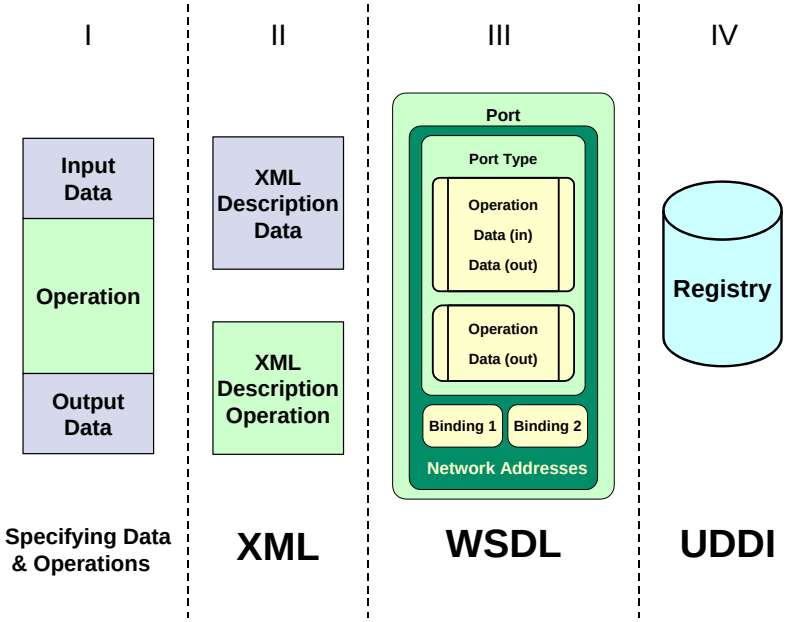

Figure 3. Web-enabling Components

THE GLOBAL INFORMATION GRID

This section gives a brief introduction to the ideas underlying the GIG. It is divided into a technical, functional, and an organizational view. These views overlap and all three of them are necessary to understand the role of the GIG in support of the concept of JC2. The main idea of JC2 is that information is obtainable by the Warfighter "*Wherever he is, Whatever he does, and Whichever system he uses*." To this end, technically interoperable and conceptually composable services relevant to the full range of application domains must be brought together in a distributed, heterogeneous, information technology.

It should be pointed out that one of the main changes with the introduction of the GIG is a change in the information policy. The GIG mandates that information will be posted immediately and will be available to every potential user without processing. The rationale behind this new concept is two-fold. First, even raw, potentially incomplete data can empower many uses in a time-constrained environment, and in fact, the knowledge gained balances the risk inherent in not waiting for the processed information. Second, data distributors may not be aware of all potential users of their data. The unidentified user would never be reached by the traditional data distributions paradigm of pushing data from the provider to the user. Currently, the Task, Process, Exploit, Disseminate (TPED) concept used in many services to provide information from the producer to the consumer. The new paradigm will be *Task, Post, Process, Use* (TPPU). The transition from the TPED concept to the TPPU concept leverages information technology and connectivity to improve the speed and quality of DoD decision-making. The terms are used as follows:

- *Task*: As in TPED, tasking includes user requests for specific information, mission management for collection platforms and sensor data processing, mission planning, and ISR asset allocation. However, in TPPU, tasking is network centric, readily accessible to all authorized users, and fully integrated with user plans and operations.
- *Post*: Data providers and users alike post data, information, and products to the GIG as soon as they are available. Thus authorized users post even raw data on the network for use before it is ingested into the conventional Processing, Exploitation, and Dissemination process. A producer of information makes it available to others by placing it on the network in a location, form, and format that other users expect. Producers of information are recognized for the inputs they provide. After using information, users post results of their work back to the network for others to process. Finished intelligence products are dis-

seminated as they were under TPED, but under the TPPU paradigm, information and computing power is continuously shared with users over high-bandwidth network communications.

- *Process:* In TPED, "processing" normally refers to the data handling required to convert raw sensor data to a useful format. In TPPU, the term can encompass exploitation, analysis, event correlation, and fusion of data and information. Information is posted directly from a sensor to a user's portal for subsequent "processing." In some cases, automated information is available in near real time. In other cases, data requires additional processing by the user to extract the required information.
- *Use:* TPPU gives the users instant access to information. Users will either pull information from known portals or receive information based on profiles or procedures such as sensor-to-shooter. This places a dual burden on both the user and information providers: *Users* must know where and when information is available and have the tools and capabilities needed to retrieve and analyze the required information. Automated functions will help provide this capability. *Producers* must be relevant by providing value-added information. In short order, producers with low or non-existent "hit rates" could be restructured or eliminated aiding the warfighter by ensuring only quality sources of information are available on the net. Finally, users can share their tailored information with other authorized users by posting it back onto the network.

Technical/Functional View of the GIG

The technical backbone actually chosen to support JC2 is the GIG, as defined in DoD Directive 8100.1. The GIG will be globally interconnected, end-to-end set of information capabilities, associated processes, and personnel for collecting, processing, storing, managing, and disseminating information on demand to Warfighters, policy makers, and support personnel. The GIG is intended to include all owned and leased communications and computing systems and services (software, data, security services, and other associated services) necessary to achieve Information Superiority.

The GIG will be Internet Protocol version 6 (IPv6) based, which means that the service-oriented architecture is likely to be web service-based, leading immediately to an extraordinary role of XML for interoperability. However, the implementation of the GIG is not exclusively committed to web services. Alternatives are evaluated as well, but even if the service architecture will not make use of web services, the role of XML for information exchange between the services has been identified as one of the main interoperability enablers. This is due to the fact that XML is used to define the namespaces, the ontologies used by the communities of interest for the exchange of information.

This development led to the establishment of the United States Department of Defense (DoD) XML Repository, which is used to collect all relevant XML tag sets used within DoD. In addition to the DoD XML Registry, where XML tag sets are simply registered, the DoD established the "DoD Metadata Registry and Clearinghouse." The DISA website places the registry's objectives in context.

"[The] Defense Information Systems Agency (DISA) is responsible for data services and other data-related infrastructures that promote interoperability and software reuse in the secure, reliable, and networked environment planned for the DoD's Global Information Grid (GIG). The Metadata Registry and Clearinghouse's primary objective is to provide software developers access to data technologies to support DoD mission applications. Through the Metadata Registry and Clearinghouse, software developers can access registered XML data and metadata components, COE database segments, and reference data tables and related meta-data information such as Country Code and US State Code. These data technologies increase the DoD's core capabilities by integrating common data, packaging database servers, implementing transformation media and using Enterprise data services built from "plug-and-play" components and data access components."

The definition of the DoD Discovery Metadata Specification (DDMS) is part of this plan and a very important step towards data-driven, net-centric interoperability. The metadata is grouped into four categories, namely security, resource, summary content, and format.

- *Security* Set elements enable the description of security classification and related fields and provide for the specification of security-related attributes and may be used to support access control.
- The *Resource* category elements provide a way to describe aspects of a data asset that

support maintenance, administration, and pedigree of the data asset.

- The *Summary* Content categories provide the description of concepts and additional contextual aspects of the data asset being tagged and include such elements as subject, description, and coverage.
- The *Format* elements provide the description of physical attributes of the asset and include elements such as file size, bit-rate or frame-rate, and mime type.

The actual version of the DDMS provides basic Summary Content elements to capture content metadata. Activities are underway to test additional Summary Content elements that provide a more robust, structured method of describing the contents of a resource. Candidates for addition to the Summary Content Category set are Person, Place, Organization, Material, and Event elements.

The Net Centric Enterprise Services (NCES) will offer their functionality to all domains of all communities of interest. Key enterprise services will include:

- *Services for Messaging*, which is the ability to exchange information among users or applications on the enterprise infrastructure (e.g., Email, Message Oriented Middleware, AOL instant messenger, Wireless Services, Alert Services, and standardized military Message Text Formats).
- *Discovery Services*, which comprise the processes for obtaining information content or services by exploiting metadata descriptions of enterprise IT resources stored in Directories, Registries, and Catalogs. Search engines are a subset of these services.
- *Mediation Services* are services that help disseminating, translating, aggregating, fusing, or integrating data and associated metadata.
- *Security Services* comprise capabilities that address vulnerabilities in networks, services, capabilities, or systems.
- *Storage Services* mean physical and virtual places to host data on the network with varying degrees of persistence (e.g., archiving, content staging).

Organizational View of the GIG

Five Mission Areas have been identified to permit users to address their needs and related development activities as shown in Figure 4. They are the *Warfighter* and the *Business* mission areas, the *Enterprise Information Environment* mission area and two Intelligence mission areas – the *National Intelligence* mission area and the *National Intelligence Enterprise Information*

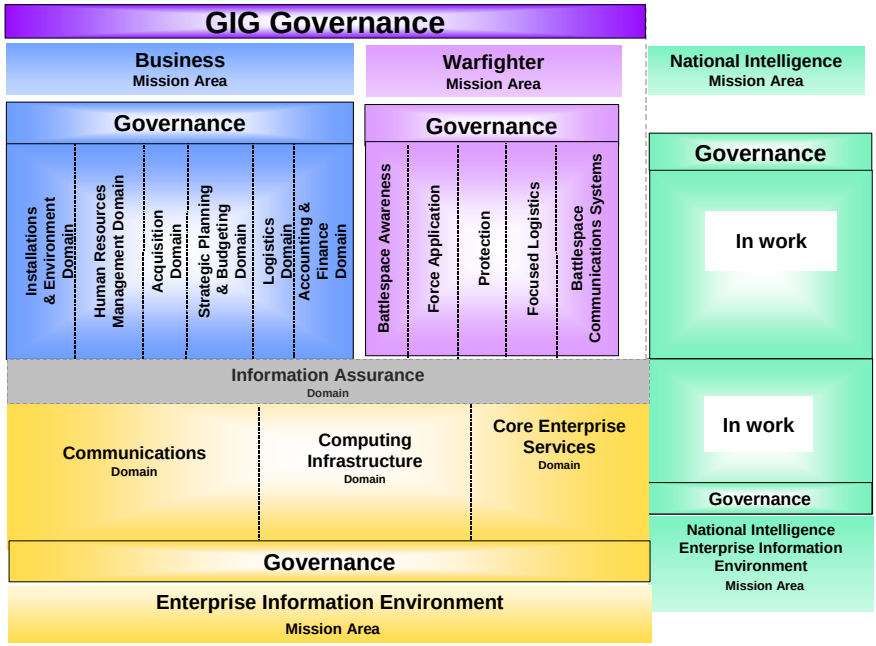

Figure 4. GIG Mission Areas

Environment mission area. Each of these Mission Areas will be divided into domains in which services will be developed. The domains are currently being defined.

From the organizational standpoint, the most important idea is the distinction between Core Enterprise Services, which are applied in all domains and which are developed and maintained centrally, and services of the different Communities of Interests (COI). The term "COI" is used to describe any collaborative group of users who must exchange information in pursuit of their shared goals, interests, missions, or business processes, and who therefore must have shared vocabulary for the information they exchange. While the services are technically identical, the organizational constraints can be described as follows:

- *Core Enterprise Services* are provided for all participating systems and services. Whenever someone needs the service of Data Mediation or Storage, etc., the same core service must be invoked, no matter to which COI the user belongs to.
- *Community of Interest Services* are provided, implemented, and maintained by the COI for the COI. Namespaces, unambiguous definitions, etc., are specific to the COI. It is therefore possible that similar services are implemented in the various COIs; however, they will be COI specific and addressing specific needs.

As there is no technical difference between a CES and a COI service. Organizationally, however, the distinction is the determining factor in who is going to maintain and update the service in the future.

As COI membership may include various data owners and producers (e.g. developers, program managers, subject matter experts, users, etc.) who need to share the same semantic knowledge, one of the main issues of COI services is enabling a common understanding of the data exchanged between the services. This is established by a common name space. The name space management efforts of all COIs are based on the Net-Centric Data Strategy of DoD. To enable information sharing between different communities, mediation services are provided to translate between the different name spaces. Figure 5 shows how the CES and COI services are organized relative to the GIG user. We define the terms as follows:

- *GIG Enterprise Services (GES):* Web-enabled capabilities and services available to users (humans and systems) on the GIG

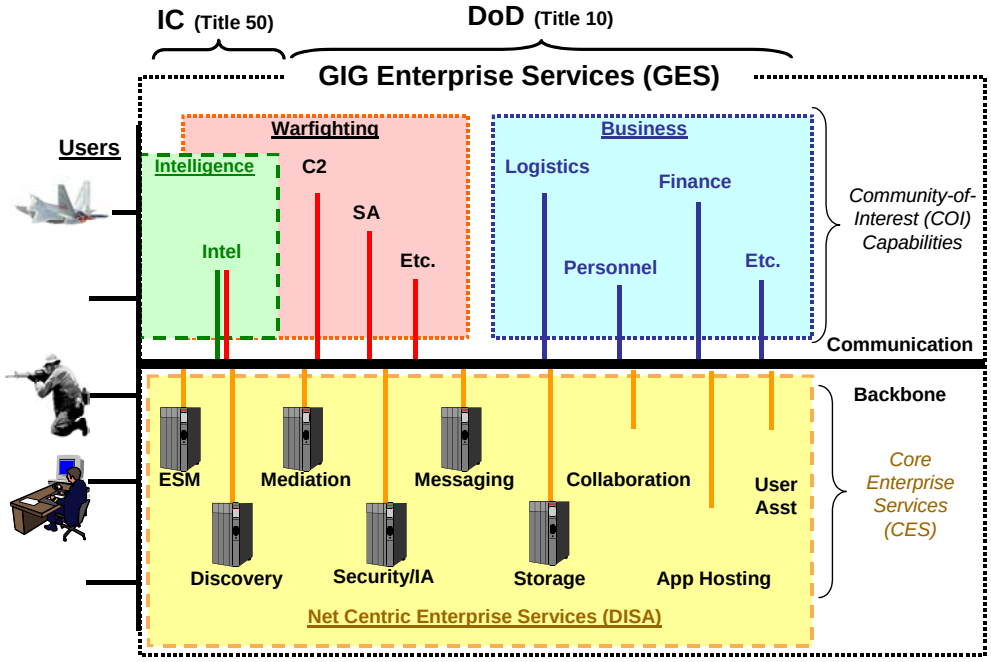

Figure 5. GIG Services

- *Core Enterprise Services (CES):* Fundamental set of computing, networking, and data sharing services provided for enterprise user support
- *Net-Centric Enterprise Services (NCES):* Program designated to provide Core Enterprise Services on the GIG
- *Domain:* Major area of functional responsibility, less than DoD enterprise scope, comprising persistent requirements and resources, spanning organizations and other Communities of Interest (COIs)
- *Community of Interest (COI):* A collaborative group of users who exchange information in pursuit of their shared goals, interests, missions or business processes

Taking into account the description of the GIG just given, there are significant implications for future M&S programs. M&S applications and services provided by programs will need to use the CES services rather than develop their own. M&S programs will also need to participate in COIs to ensure that their data is visible and accessible to GIG users.

MODELING & SIMULATION IN THE GIG

This last section introduces the notion of M&S in the context of the GIG. Issues include the notion of M&S services and the use of common standards and procedures.

Modeling & Simulation Community of Interest

As pointed out earlier one of the main organizational principles is the use of Communities of Interest (COI) of GIG users. In June 2004, the Defense Modeling & Simulation Office stood up the M&S Community of Interest and chartered its activities with an Operating Guideline.

The mission is to establish an M&S COI, ensure the integration of M&S services into the GIG, and provide a forum for the M&S community to work within the COI to influence, advise, and educate the more global community with regard to M&S. The purpose is to identify M&S web-based services for inclusion in the GIG, make M&S data and services visible to the GIG user community, and to coordinate with other COIs. Like other COIs, M&S will manage its Metadata registry, establish taxonomies and ontologies to enable discovery and retrieval services, and conduct prototype experiments or demonstration exploring the most appropriate services to enable GIG users in the key tasks of planning, training, sense-making and decision making. To be effective the M&S COI must promote Service and Joint collaboration in the use of emerging technology to adapt services for the GIG and recommend standards and architectures that will best support M&S as and Enterprise Service. Coordination across other communities will be critical as M&S has roles that span several domains. The final shape of M&S services will depend upon the design and execution of near-term proof of principle demonstrations.

DMSO chairs the M&S COI, which will include representation from the stakeholders of M&S across the DoD. Like the COI the membership is under construction and is expected to be flexible, expanding to include new participants with services to provide or users with needs to be addressed.

High Level Architecture

IEEE1516 High Level Architecture (HLA) standard is currently under review to identify necessary improvements. The advent of the GIG will influence the evaluation of web-based standards and how they will play with the HLA as it is evolved.

Of particular interest is to make the concepts of the High Level Architecture generally available to the GIG users interested in distributed simulation applications. To this end, a web-based version of HLA software products, in particular the Runtime Infrastructure (RTI), in the Core Enterprise Service domain is an option currently considered.

Common Reference Data Models: C2IEDM

The DoD Net-Centric Data Strategy explicitly excludes the development of a common enterprise-wide data model. The objective is to develop composable services that are location independent and loosely coupled based on standardized service support environments. The use of metadata supporting mediation services is the current way to go.

However, in order to generate composable solutions, common reference models are necessary, as they enable semantic interoperability, i.e., the services share the same interpretation of the exchanged data. These reference models can be implicit (common sense) or explicit (model based data management). While not yet established, the explicit common reference model is the approach recommended by the authors. In addition, this approach is already well established by the Data Management instances of NATO.

Based on the positive results within NATO, the Command and Control Information Exchange Data Model (C2IEDM) has been identified as a promising starting point for evolving a common reference model in the military domain, and in particular, in command and control. The Joint and Combined nature of C2IEDM is of particular interest for projects like the Joint National Training Capability (JNTC). The applicability in the net-centric context of NATO was shown in the ongoing Multilateral Interoperability Program (MIP). The use of C2IEDM as a hub for a common reference model is considered by various experts within ADUSD (Interoperability & Network Centric Warfare)/ ODUSD (Advanced Systems & Concepts) and was presented on several workshops. An expert workshop found that the use of C2IEDM to address challenges of interoperability and composability in M&S was more than feasible. Work using C2IEDM is now underway in linking M&S applications to operational databases.

SUMMARY

The GIG is coming and while we do not now know its final shape, we know it will be based on a service-oriented architecture that will be enabled by web standards. M&S is a key component in transformation and to live up to it's potential, must move with the warfighter to this new information environment. Over the past two years, the XMSF project has conducted a series of experiments that have tested the viability of web standards to support critical M&S functions. Based on the positive results of these endeavors and the need to play as an equal partner with the warfighter in his IT environment, DMSO is creating the M&S COI. It is through this COI that the M&S community will have a voice in the evolution of standards, taxonomies, ontologies, name spaces, registries and services that will form our common GIG environment.

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The following references have been used to prepare this tutorial and will give further insight into the topics coped with. Please do not hesitate to contact the authors for further sources and support.

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